

Supplemental online content for:

Association Between Frailty and Time Alive and At Home After Cancer Surgery Among Older Adults: A Population-Based Analysis

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J Natl Compr Canc Netw 2022;20(11):1223–1232.e8

eFigure 1: Probability of Remaining Alive and At Home From the Time of Surgery

eTable 1: Data Sources

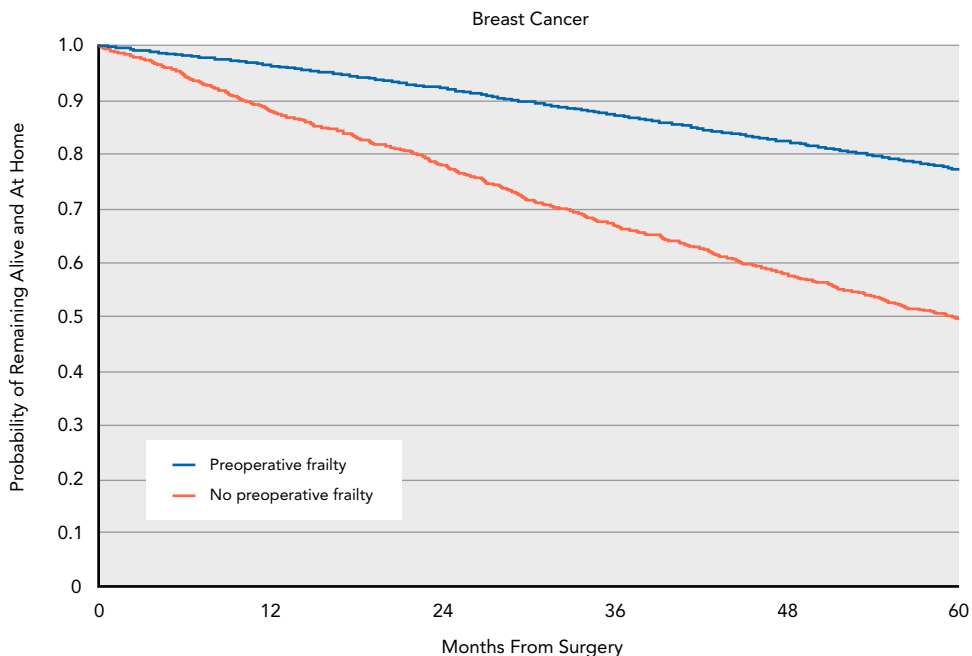
eTable 2: Strategy for Cohort Creation

eTable 3: Definition of Covariates

eTable 4: Unadjusted Association Between Preoperative Frailty and Remaining Alive and At Home

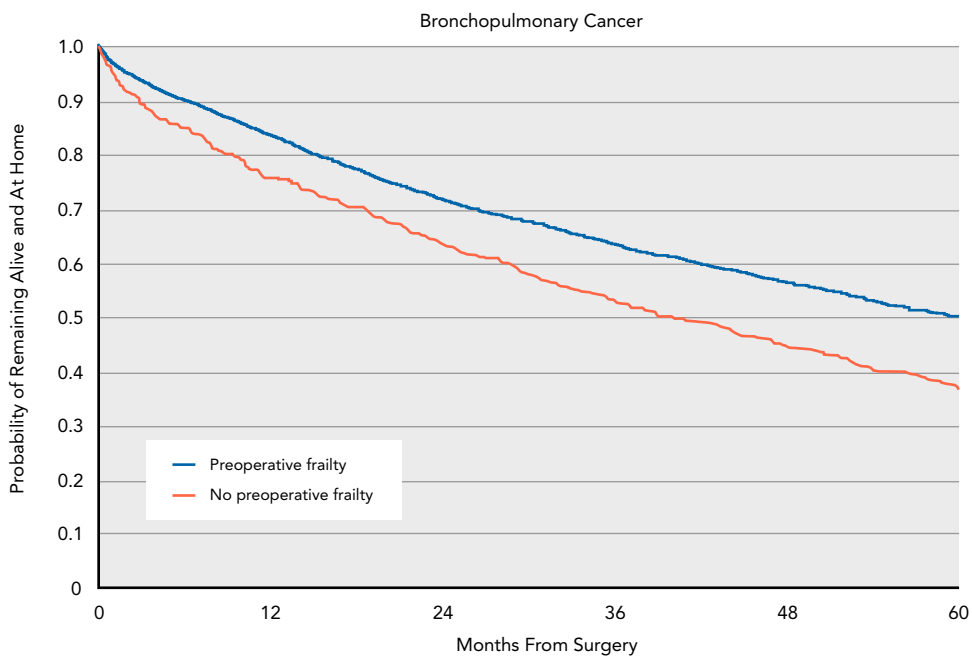
eTable 5: Adjusted HRs Showing Effect of Preoperative Frailty on Hazards of Remaining Alive and At Home After Cancer Surgery

A



Number at risk		0	12	24	36	48	60
Preoperative frailty		1,715	1,503	1,221	914	702	519
No preoperative frailty		21,096	20,272	17,678	14,746	12,105	9,650

B

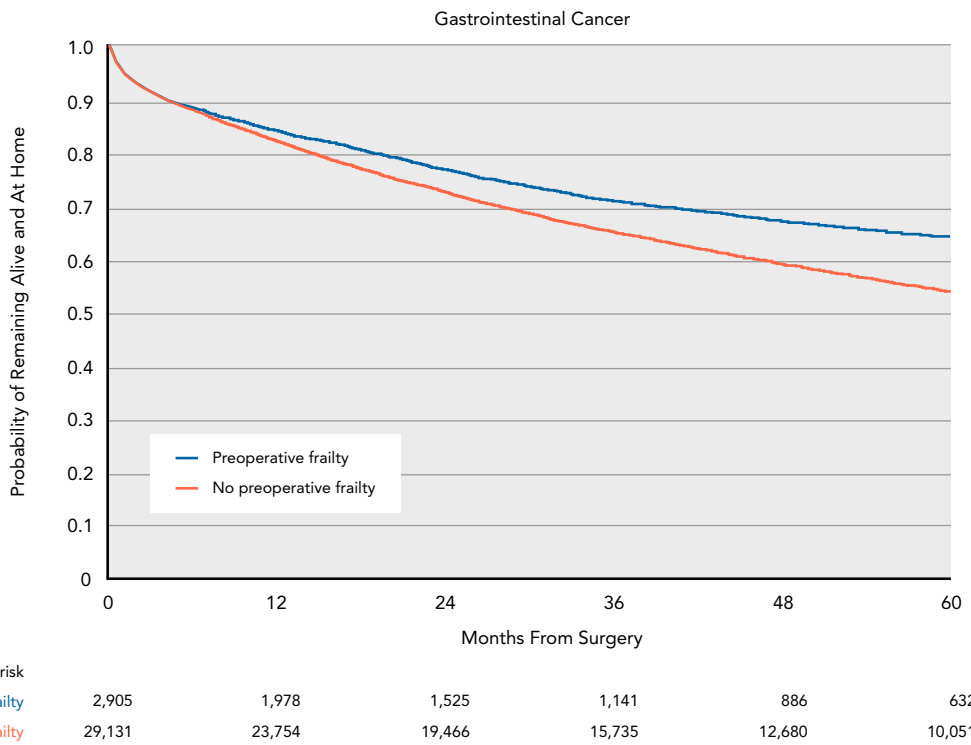


Number at risk		0	12	24	36	48	60
Preoperative frailty		527	398	314	241	168	113
No preoperative frailty		6,902	5,733	4,434	3,446	2,639	1,974

Figure 1. Probability of remaining alive and at home from the time of surgery for **(A)** breast and **(B)** bronchopulmonary cancers.

(continued on next page)

C



D

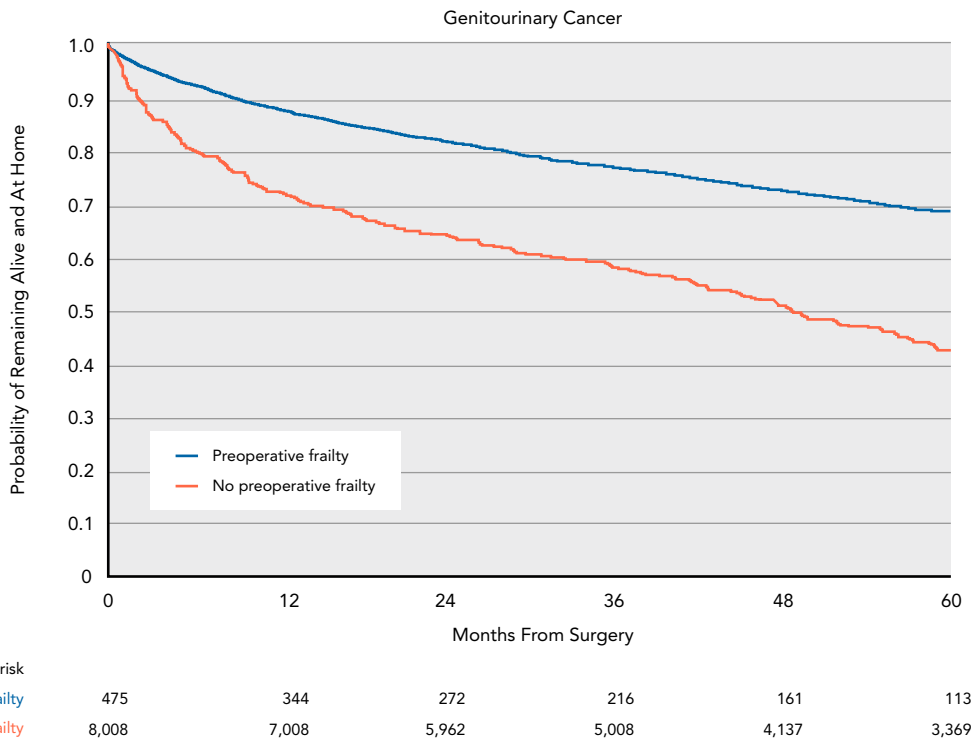
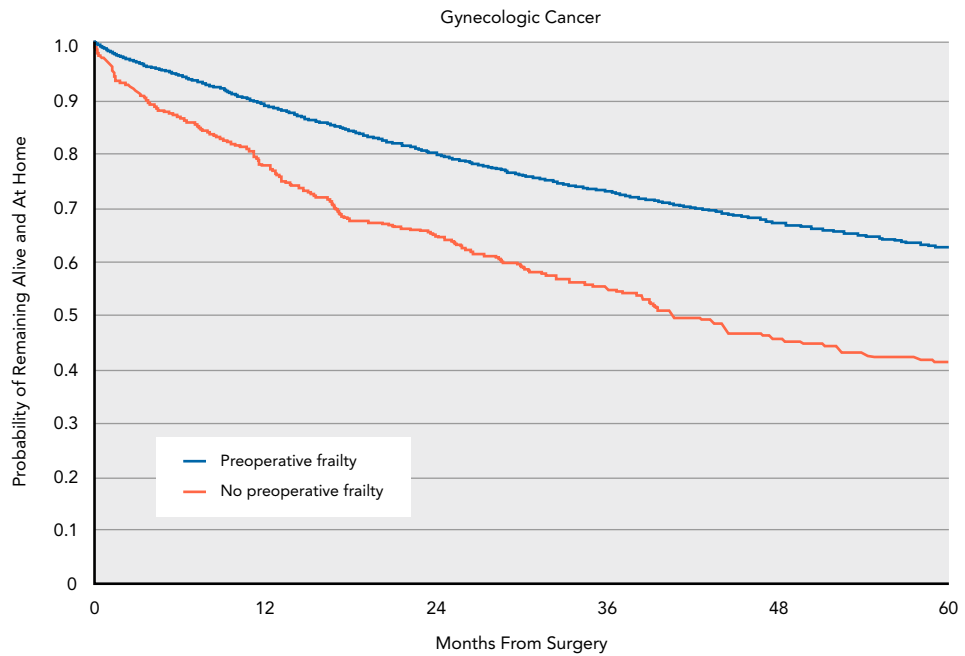


Figure 1 (cont.). Probability of remaining alive and at home from the time of surgery for **(C)** gastrointestinal and **(D)** genitourinary cancers.

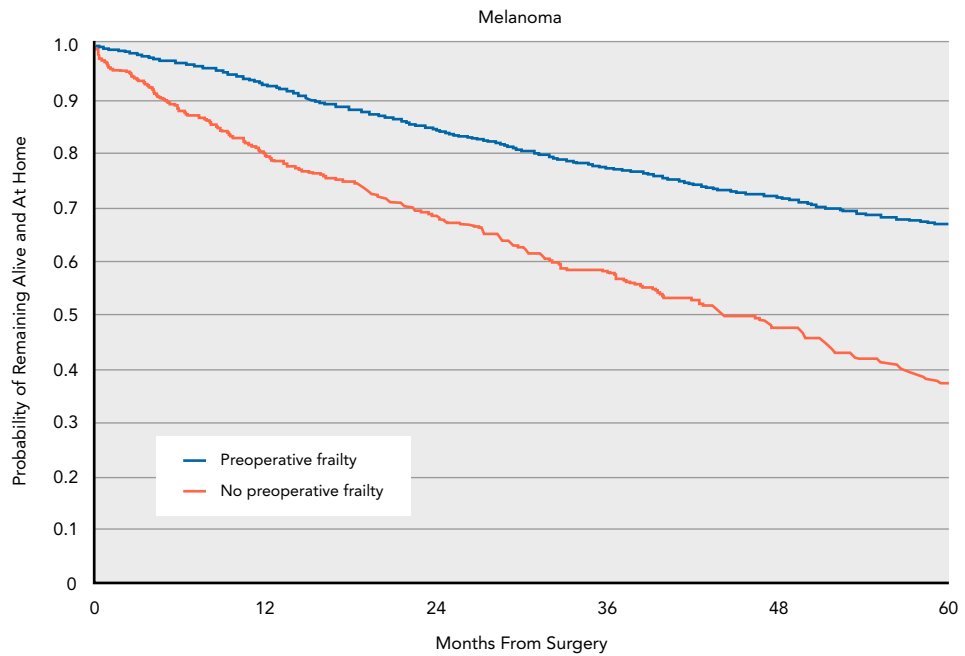
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E



Number at risk							
Preoperative frailty	412	318	234	161	118	90	
No preoperative frailty	6,246	5,489	4,489	3,579	2,856	2,314	

F

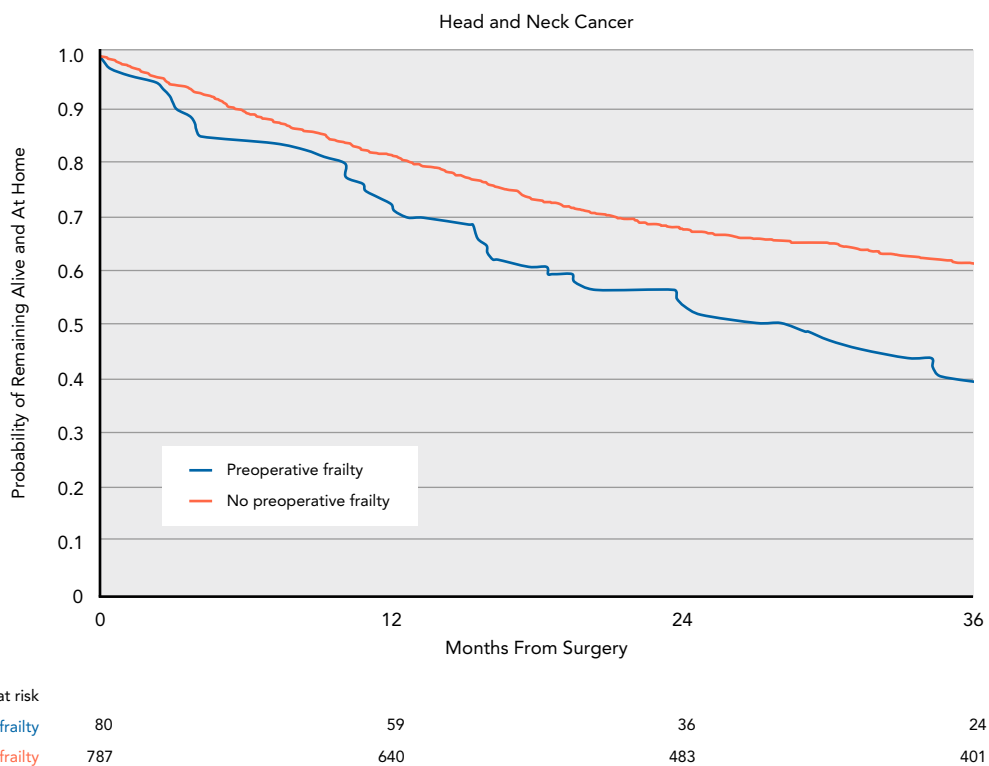


Number at risk							
Preoperative frailty	329	260	207	151	108	73	
No preoperative frailty	3,424	3,161	2,610	2,060	1,659	1,292	

eFigure 1 (cont.). Probability of remaining alive and at home from the time of surgery for **(E)** gynecologic cancer and **(F)** melanoma.

(continued on next page)

G



eFigure 1 (cont.). Probability of remaining alive and at home from the time of surgery for **(G)** head and neck cancers. Data for head and neck cancers are reported up to 36 months due to small numbers at risk beyond that time point.

eTable 1. Data Sources

Database	Description
Ontario Cancer Registry (OCR)	The OCR is a passive, provincial registry of all incident cancer diagnoses in Ontario. It includes 96% of cancer diagnoses in the province. Information included in the registry: cancer topography and morphology/histology, and details of diagnosis (eg, types of contributing information to the diagnosis, dates).
Activity Level Reporting (ALR) of Cancer Care Ontario	Cancer Care Ontario maintains a database of cancer-specific services, including consultations, chemotherapy, and radiotherapy, provided by regional cancer centers in the province. Because all radiotherapy is delivered at regional cancer centers, this database is a complete source for this information. However, because not all patients with cancer who receive surgery or chemotherapy visit a regional cancer center, this database cannot be used as a population data source for those treatments.
Registered Persons Database (RPDB)	The RPDB is an ICES database derived from all administrative data sources and provides demographic data, including age, patient residence, vital status, date of last contact with the healthcare system, and Ontario Health Insurance Plan eligibility.
Ontario Office of the Registrar General (ORG)	The ORG contains gold standard vital status data for all Ontarians. According to the Vital Statistics Act, it is mandatory to register all deaths occurring in the province.
Ontario Marginalization Index (ON-Marg)	ON-Marg is a specialized database using census data to profile relative area-level marginalization dependency, deprivation, ethnic concentration, and instability at various geographic levels in Ontario.
Ontario Health Insurance Plan (OHIP)	The OHIP database contains all physician billing data, including information on diagnoses as well as services provided, such as receipt of surgery, chemotherapy, and radiotherapy.
National Ambulatory Care Reporting System (NACRS)	The NACRS collects data elements describing emergency health services provided by emergency departments in Ontario, including diagnoses, procedures, and administrative information such as wait times.
Ontario Drug Benefit (ODB) database	The ODB database contains all information for prescription drugs dispensed by community pharmacies and long-term care/nursing facilities. It covers all seniors (age ≥ 65 y) and individuals on social assistance for all prescriptions listed on the provincial formulary.
New Drug Funding Program (NDFP)	The NDFP contains information for high-cost drugs for all ages, including new and often expensive systemic therapies.
Assistive Devices Program (ADP)	The ADP captures amounts reimbursed to individuals based on claims for medical equipment (eg, walker, insulin pump).
Home Care Data (HCD)	The HCD includes information on home care services provided by Ontario's Community Care Access Centres (CCACs) established by the Ministry of Health to provide access to government-funded home and community services. It captures all information on services provided by or coordinated by CCACs, including type of services, service dates, and functional assessments.
Continuing Care Reporting System (CCRS)	The CCRS contains information on individuals receiving facility-based continuing care, including medical long-term care, rehabilitation, geriatric assessment, respite care, palliative care, and nursing home care.
Immigration, Refugees and Citizenship Canada Permanent Resident Database (IRCC-PD)	The IRCC-PD includes information on immigration, permanent residence, and citizenship since 1985.

eTable 2. Strategy for Cohort Creation			
Cancer Site	Subtype	ICD-O-3 Code	Resection Codes (CIHI CCI Codes)
Breast		C50.0–C50.9	Excision partial: 1YM87 ^{MA} , 1YM88 ^{MA} (with reconstruction) Mastectomy: 1YM89 ^{MA} , 1YM90 ^{MA} (with reconstruction), 1YM91 ^{MA} (radical), 1YM92 ^{MA} (radical with reconstruction)
Melanoma		C44.2–C44.9	Head and neck: 1YF87 ^{MA} , 1YG87 ^{MA} Trunk and abdomen: 1YS87 ^{MA} Extremities: 1YR87 ^{MA} (axilla), 1YT87 ^{MA} (arm), 1YU87 ^{MA} (hand), 1YV87 ^{MA} (leg), 1YW87 ^{MA} (foot) Other: 1YZ87 ^{MA} (NEC)
Gastrointestinal	Esophageal	C15.0–C15.9	1NA87 ^{MA} , 1NA88 ^{MA} , 1NA89 ^{MA} , 1NA90 ^{MA} , 1NA91 ^{MA} , 1NA92 ^{MA} Except: 1NA87BA ^{MA} , 1NA87DA ^{MA} , 1NA87LA ^{MA}
	Gastric	C16.0–C16.9	1NF87 ^{MA} , 1NF89 ^{MA} , 1NF90 ^{MA} , 1NF91 ^{MA} , 1NF92 ^{MA} Except: 1NF87BA ^{MA} , 1NF87DA ^{MA} , 1NF87LA ^{MA}
	Hepato-pancreaticobiliary	Liver: C22.0, C22.1 Biliary: C23.9, C24.0, C24.1, C24.8, C24.9 Pancreas: C25.0–C25.9	Liver: 1OA87 ^{MA} Bile ducts: 1OE87 ^{MA} , 1OE89 ^{MA} Except: 1OE87BA ^{MA} , 1OE89BA ^{MA} Pancreas: 1OJ87 ^{MA} (distal), 1OJ89 ^{MA} (distal), 1OK87 ^{MA} (Whipple), 1OK89 ^{MA} (Whipple), 1OK91 ^{MA} (Whipple)
	Colorectal and enteric	Small bowel: C17.0–C17.9 Colon: C18.0–C18.9 Rectum: C19.9, C20.9	Small bowel: 1NK87 ^{MA} Except: 1NK87BA ^{MA} , 1NK87DA ^{MA} , 1NK87LA ^{MA} Colon: 1NM87 ^{MA} , 1NM89 ^{MA} , 1NM91 ^{MA} Except: 1NM87BA ^{MA} , 1NM87DA ^{MA} , 1NM87LA ^{MA} Rectum: 1NQ87 ^{MA} , 1NQ89 ^{MA} Except: 1NQ87BA ^{MA} , 1NQ87DA ^{MA} , 1NQ87LA ^{MA}
Genitourinary (excluding penis, seminal vesicle, urethra)	Kidney and ureter	C64.9, C65.9, C66.9	Kidney: 1PC87 ^{MA} , 1PC89 ^{MA} , 1PC91 ^{MA} , 1PE87 ^{MA} , 1PE89 ^{MA} , 1PE91 ^{MA} Ureter: 1PG87 ^{MA} , 1PG89 ^{MA} Except: 1PG87BA ^{MA} , 1PG89BA ^{MA}
	Bladder	C67.0–C67.9	1PL87 ^{MA} , 1PM87 ^{MA} , 1PM89 ^{MA} , 1PM90 ^{MA} , 1PM91 ^{MA} , 1PM92 ^{MA} Except: 1PL87BA ^{MA} , 1PL89BA ^{MA} , 1PM87BA ^{MA} , 1PM89BA ^{MA}
	Prostate	C61.9	1QT87 ^{MA} , 1QT91 ^{MA} Except: 1QT87BA ^{MA}
	Adrenal	C74.0, C74.1, C74.9	1PB87 ^{MA} , 1PB89 ^{MA} Except: 1PB87DA ^{MA} , 1PB89DA ^{MA}
Gynecologic (excluding vulva)		Vagina: C52.9 Cervix: C53.0, C53.1, C53.8, C53.9 Uterus: C54.0, C54.1, C54.2, C54.3, C54.8, C54.9, C55.9 Ovaries: C56.9, C57.0, C57.1, C57.2, C57.3, C57.4 Others: C57.7, C57.8, C57.9	Ovary and fallopian: 1RB87 ^{MA} , 1RB89 ^{MA} , 1RF87 ^{MA} , 1RF89 ^{MA} Uterus: 1RM87 ^{MA} , 1RM89 ^{MA} , 1RM91 ^{MA} Except: 1RM87BA ^{MA} , 1RM89 ^{MA} Cervix: 1RN87 ^{MA} , 1RN89 ^{MA} , 1RN91 ^{MA} Except: 1RN87CR ^{MA} , 1RN89CR ^{MA} Vagina: 1RS87 ^{MA} , 1RS89 ^{MA} Except: 1RS87AA ^{MA} , 1RS89CR ^{MA}
Bronchopulmonary		C30.0–C34.9, C38.1–C39.9	Lobectomy: 1GR87 ^{MA} , 1GR89 ^{MA} , 1GR91 ^{MA} , 1GT87 ^{MA} Pneumonectomy: 1GT89 ^{MA} , 1GT91 ^{MA}
Oropharyngeal		C00.0–C14.8, C76.0	1ED87 ^{MA} , 1ED91 ^{MA} , 1FJ87 ^{MA} , 1FX87 ^{MA}

Abbreviations: CCI, Canadian Classification of Health Interventions; CIHI, Canadian Institute for Health Information.

eTable 3. Definition of Covariates

Variable	Definition	Source	Type	Analysis Format
Age	Year of age at diagnosis	OCR	Categorical	70–74 y 75–79 y 80–84 y ≥85 y
Sex	Sex	OCR RPDB	Dichotomous	Male/Female
Material deprivation	Measure of the inability of individuals or households to afford goods or activities typical in a society at a given time ^a	Canadian Census RPDB ON-Marg	Categorical	First (least deprived) Second Third Fourth Fifth (most deprived)
Rural residence	Determined with postal code of residence as per national census definition of a community with <10,000 people ^b	RPDB	Dichotomous	Urban/rural
Immigration status	Immigrant defined as permanent residence granted or citizenship in 1985 or later ^c	IRCC-PD	Dichotomous	Immigrant Nonimmigrant (long-standing resident)
Year of diagnosis	Year of cancer diagnosis date	OCR	Ordinal	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Comorbidity burden	Measured using the Johns Hopkins Adjusted Clinical Groups system score based on health service use with a 24-month look-back window before the date of cancer diagnosis whereby the 32 Aggregated Diagnosis Groups (ADGs) are summed to create a total score ^{d,e}	CIHI-DAD CIHI-SDS OHIP	Dichotomous	<10 ≥10
Preoperative frailty	Measured using the Johns Hopkins Adjusted Clinical Groups system frailty marker ^f	CIHI-DAD CIHI-SDS NACRS	Dichotomous	Frailty No frailty
Cancer type	Type of primary cancer based on ICD-O-3 codes (supplemental eTable 2)	OCR	Categorical	Breast Skin (melanoma) Gastrointestinal Genitourinary Gynecologic Bronchopulmonary Oropharyngeal
Intensity of surgery	Intensity of the surgical procedure in terms of baseline risk, using a consensus-validated definition ^g	CIHI-DAD CIHI-SDS	Dichotomous	Low High
Neoadjuvant therapy	Receipt of radiation therapy or chemotherapy from 180 days before date of surgery to date of surgery	OHIP ALR	Dichotomous	Yes No
Adjuvant therapy	Receipt of radiation therapy or chemotherapy with first treatment administered within 180 days from the date of surgery	OHIP ALR	Dichotomous	Yes No

Abbreviations: ALR, Activity Level Reporting; CIHI, Canadian Institute for Health Information; DAD, Discharge Abstract Database; IRCC-PD, Immigration, Refugees and Citizenship Canada Permanent Resident Database; NACRS, National Ambulatory Care Reporting System; OCR, Ontario Cancer Registry; OHIP, Ontario Health Insurance Plan; ON-Marg, Ontario Marginalization Index; RPDB, Registered Persons Database; SDS, Same-Day Surgery Database.

^aMatheson FI, Dunn JR, Smith KL, et al. Development of the Canadian Marginalization Index: a new tool for the study of inequality. *Can J Public Health* 2012;103:S12–16.

^bDu Plessis V, Beshiri R, Bollman R. Definitions of rural. Ottawa, Ontario, Canada: Statistics Canada, Agriculture Division; 2002.

^cChiu M, Lebenbaum M, Lam K, et al. Describing the linkages of the immigration, refugees and citizenship Canada permanent resident data and vital statistics death registry to Ontario's administrative health database. *BMC Med Inform Decis Mak* 2016;16:135.

^dReid RJ, Roos NP, MacWilliam L, et al. Assessing population health care need using a claims-based ACG morbidity measure: a validation analysis in the Province of Manitoba. *Health Serv Res* 2002;37:1345–1364.

^eReid RJ, MacWilliam L, Verhulst L, et al. Performance of the ACG case-mix system in two Canadian provinces. *Med Care* 2001;39:86–99.

^fSternberg SA, Wershof Schwartz A, Karunanathan S, et al. The identification of frailty: a systematic literature review. *J Am Geriatr Soc* 2011;59:2129–2138.

^gSchwarze ML, Barnato AE, Rathouz PJ, et al. Development of a list of high-risk operations for patients 65 years and older. *JAMA Surg* 2015;150:325–331.

eTable 4. Unadjusted Association Between Preoperative Frailty and Remaining Alive and At Home by Postoperative Time Interval^a

Postoperative Time Interval	HR ^b (95% CI)
0–30 days	2.10 (1.88–2.35)
31–90 days	2.44 (2.18–2.73)
91–180 days	2.10 (1.86–2.36)
181–360 days	1.99 (1.80–2.17)
1–5 years	1.88 (1.80–1.97)

Abbreviation: HR, hazard ratio.

^aUnivariable extended Cox regression with time-varying effects.

^bHazards of death or admission to nursing home (HR >1 indicates higher hazard of not being alive and at home).

eTable 5. Adjusted HRs Showing Effect of Preoperative Frailty on Hazards of Remaining Alive and At Home After Cancer Surgery, Stratified by Cancer Type^a

Postoperative Time Interval	Breast Cancer HR ^b (95% CI)	Bronchopulmonary Cancer HR ^b (95% CI)	Gastrointestinal Cancer HR ^b (95% CI)	Genitourinary Cancer HR ^b (95% CI)	Gynecologic Cancer HR ^b (95% CI)	Head and Neck Cancers HR ^b (95% CI)	Melanoma HR ^b (95% CI)
0–30 days	1.61 (0.91–2.87)	1.37 (0.90–2.07)	1.69 (1.48–1.92)	1.23 (0.73–2.05)	1.88 (1.09–3.24)	1.29 (0.29–5.80)	4.90 (2.45–9.80)
31–90 days	1.57 (0.99–2.48)	1.76 (1.20–2.59)	2.02 (1.76–2.34)	2.85 (2.00–3.97)	2.23 (1.42–3.51)	1.06 (0.37–3.02)	1.56 (0.69–3.51)
91–180 days	2.36 (1.74–3.20)	1.24 (0.81–1.90)	1.66 (1.41–1.96)	1.98 (1.35–2.88)	1.63 (1.01–2.63)	1.22 (0.51–2.90)	3.12 (1.86–5.23)
181–360 days	2.52 (2.03–3.11)	1.49 (1.10–2.00)	1.46 (1.27–1.68)	1.60 (1.15–2.24)	1.51 (1.07–2.12)	1.04 (0.49–2.20)	1.87 (1.24–2.80)
1–5 years	1.78 (1.62–1.96)	1.31 (1.12–1.54)	1.43 (1.33–1.53)	1.42 (1.16–1.73)	1.59 (1.31–1.92)	1.63 (1.09–2.43)	1.76 (1.44–2.15)

Abbreviation: HR, hazard ratio.

^aMultivariable extended Cox regression with time-varying effects.

^bHazard of death or admission to nursing care (HR <1 indicates higher probability of remaining alive and at home). Adjusted for age (categorical), sex, rural residence, comorbidity burden, material deprivation, immigration status, stage at diagnosis, year of surgery, neoadjuvant therapy, adjuvant therapy, and intensity of surgical procedure.